Letters to the Editor

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CYCLOTRON RESONANCE IN NATURAL CRYSTALS OF GRAPHITE

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Cyclotron resonance in natural crystals of graphite as observed by Galt, Yager and Dial (1956) was analysed by Lax and Zeiger (1957) and also by Nozieres (1958). While the interpretation given by Lax and Zeiger could not explain the observed phenomena satisfactorily, that of Nozieres explains the linewidth as due to a spread in the effective mass value of the carriers, based on a complex band structure. But both Williamson *et al* (1966) and Schroeder *et al* (1968) appear to favour carriers with a single effective mass though they do not agree as to the sign of the carriers.

We propose here an interpretation of the observed cyclotron resonance of natural crystals of graphite, taking account of the misalignments present in it (Ray 1959; Ray and Bhattacharya 1965) which affects bulk properties also. This can possibly account for the apparent mass spread of carriers envisaged by Nozieres, without having to assume a complexity in the band structure.

X-ray intensity measurement (Ray and Bhattacharya, 1965) indicates a continuous distribution of the c-axes of the misaligned crystallites within a limit ing angle ϕ_m with respect to the c-axis of the natural crystal. The general expression for the angular frequency of precession ν_p will in this case be given by

$$\nu_p^2 = \left(\frac{eH \cos \phi_m}{m_\perp c} \right)^2 + \left(\frac{eH \sin \phi_m}{\sqrt{m_\perp m_\parallel} \cdot c} \right)^2$$

where H = the magnetic field along c-axis of the natural crystal,

$m_\perp$ = effective mass of carriers for motion along the basal plane

$m\|$ = effective mass of carriers for motion along the c-axis and

e and c have the usual meanings.

Resonance will occur for the carriers in those crystallites for which $\nu_p = \nu_c$ (ν_c is the frequency of the incident polarised radiation). It is evident from the above equation that by changing the value of the applied magnetic field, ν_p for different sets of crystallites may be made to equal ν_c. As a result, the expected peak would be broadened, as determined by the value of ϕ_m. Thus the consideration of misalignment present in natural crystals of graphite produces an effect similar to that due to a spread in the effective mass of carriers, obtained by Nozieres, (1958). The broadening of a peak (fundamental or harmonics) due to this effect will be given by $H\left(\frac{1-\cos\phi_m}{\cos\phi_m}\right)$ for moderate values of ϕ_m. To get the true broadening corrections due to other of effects (relaxation etc.) should be applied.

A preliminary calculation based on the cyclotron resonance data of Willamson *et al* (1966) shows that in their natural crystal broadening with field due to this effect can be explained with a misalignment of the crystallites to the extent of about 16°. This agrees very well with our direct X-ray measurement of single crystals of Ceylon graphite (1965) which appears to be a constant feature in most of the samples.

The details of this analysis will be dealt with in a paper to be published shortly.

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